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XXII. *On the extensive Atmosphere of Mars.* By Sir JAMES SOUTH, F.R.S.
Communicated by His Royal Highness the President.

Read June 16, 1831.

THAT several of the planets as well as that which we inhabit are surrounded by atmosphere, astronomical observations have long since established; the extent, however, to which in particular planets such atmospheres are diffused, is as yet not satisfactorily determined. The former rests principally upon phenomena observed on the planets' discs, whilst the latter derives its support chiefly from those detected at or near their respective limbs. Every night, nay almost every hour, may give us indication of the one, whilst years are sometimes necessary, as in the case of planets unattended by satellites, to help us to the other; thus the hypothesis of the *extensive* atmosphere of Mars derives its origin from the observations of CASSINI and ROËMER, and has stood more than a century and a half without refutation or support.

The observations to which I allude formed part of a series undertaken for the determination of the parallax of Mars, and are recorded in the *Mémoires de l'Académie des Sciences*. CASSINI's were made at Briare and at La Charité sur Loire; whilst ROËMER's was obtained at the Royal Observatory of Paris.

Of the Briare observation CASSINI says, "Le premier Octobre 1672 à 2^h 45^m du matin à Briare, Mars vû par une lunette de trois pieds, sembloit toucher par son bord septentrional, la ligne droite tirée par la première et par la seconde de l'eau d'Aquarius marquée ψ , d'où il n'étoit plus éloigné que de six minutes. Cette étoile paroissoit si diminuée et si affoiblie de lumière, qu'on ne la pouvoit plus distinguer ni à la vue simple, ni par une lunette un peu plus foible."—*Mém. de l'Acad.* tome vii. p. 357.

The La Charité and Paris observations entitled "Eclipse de la Moyenne ψ dans l'eau d'Aquarius" are thus narrated: "Quoique le ciel fut alors assez beau de part et d'autre, et que l'on vit Mars pendant un assez long espace de temps,

on ne vit point l'étoile moyenne ψ , qui devoit être cachée par son disque. Le diamètre de Mars étoit alors de 25 secondes.—Mém. de l'Acad. tom. vii. p. 358.

“ Les nuages qui survinrent ne permirent pas d'en voir la sortie ; et l'on ne savait pas même si on l'auroit pû voir immédiatement, car trois quarts d'heure après le ciel s'étant découvert à Paris, M. ROËMER la chercha attentivement autour de Mars, et il ne la trouva qu'après l'attention de deux minutes, quand elle étoit déjà éloignée du bord oriental de Mars de deux tiers de son diamètre. C'étoit alors $11^h 15^m$, et le parallèle de l'étoile coupoit le diamètre de Mars en raison de 2 à 3. Il commença de la voir sans difficulté, quand elle étoit éloignée de Mars de trois quarts de son diamètre.”—Mém. de l'Acad. tom. vii. p. 359.

Hence we learn that a star of the fifth magnitude at the distance of six minutes from the planet Mars became invisible to CASSINI ; and that after occultation by the planet, the same star could not be detected by ROËMER, till the planet's limb had receded from it, almost seventeen seconds of a degree. Experience, however, has long shown us that stars of the same magnitude are visible even when in actual contact with the moon's enlightened limb ; to what cause then is the invisibility of the star when in the vicinity of Mars referable ? CASSINI attributed it to the atmosphere of Mars ; and although it seems difficult to imagine one of such *enormous extent* as the Briare observation would require, still, as any other hypothesis would involve us in greater difficulty, I shall adopt it, and shall present it, as also the comments which precede it, in CASSINI's own words : “ Cette difficulté de voir cette étoile de la cinquième grandeur très proche de Mars est considérable, d'autant qu'il n'y a point de difficulté à voir des étoiles de la même grandeur jusqu'au bord de la lune. Ce qui pourroit fair juger que Mars est environné de quelque atmosphère.”—Mém. de l'Acad. tom. vii. p. 359.

Admitting, then, that an *extensively* diffused atmosphere of Mars is indicated by the observations above quoted, let us see if modern observations can confirm it.

On the 27th October 1783, Sir WILLIAM HERSCHEL, with a new 20-feet Reflector of 18.7 inches aperture, saw a star of the 13th or 14th magnitude at a distance of two minutes and fifty-six seconds from the planet, “ not otherwise

affected by the approach of Mars, than what the brightness of its superior light might account for.”—Vide Phil. Trans. vol. lxxiv. p. 272.

On the 19th of February 1822, in Blackman-street, a star of the 9th or 10th magnitude was for several hours seen in the field of the 5-feet Equatorial with the planet Mars. At a distance of one minute and forty-three seconds of a degree from the planet, (which took place at 11^h 15^m sidereal time,) its splendour suffered no sensible diminution.

On the following night a star 42 Leonis, of the 6th magnitude, was in the field of the same instrument with Mars, and the planet's progress towards the star was observed micrometrically for several hours; nor did the star suffer any loss of its brilliancy as its distance from the planet diminished.

Fatigued by previous watchings, at about two in the morning I retired to rest; but thinking it probable that the star would undergo occultation, accompanied by my brother Mr. HENRY SOUTH I returned to the instrument about 4 o'clock, and found Mars about half his own diameter from the star. The planet had about twenty-four degrees of altitude; its limb was at times well defined and steady, at other times extremely unsteady; the star was comparatively steady*, could be kept tolerably well upon the micrometer-wire, and was of a beautiful blue colour. At 15^h 3^m 23^s.3 sidereal time, it was seen admirably defined, and was distant from the limb of the planet a diameter of one of the micrometer-wires, equal nearly to one second of a degree; from which time till 15^h 3^m 53^s the planet's limb was so extremely unsteady and ill defined, that the precise moment of occultation could not be obtained.

After emersion, at 15^h 20^m 38^s.3 the star was seen when it was about 1½ diameter of the wire, or one second and a half from the limb; it was almost indigo blue; and the contrast between it and the planet, which was of a deep red, was exquisitely beautiful. By reference to the double star 48 ϵ Cancræ, some idea of it may be entertained, if we regard the larger of its stars as Mars, and the smaller as 42 Leonis. At the time of observation the planet had passed his opposition only forty-seven hours, and his apparent diameter as measured with the micrometer, was sixteen seconds and six tenths.

* This steadiness of one sidereal object, as contrasted with the extreme unsteadiness of another, seen under similar circumstances of atmosphere and altitude, has *long* been familiar to me, and is a phenomenon to which, on some future occasion, I shall probably invite the Society's attention.

The phenomena were also witnessed by Mr. HENRY SOUTH, and his observations strictly accorded with my own. To render our results as independent as possible of optical misrepresentation, his instrument was my Gregorian reflector, by WATSON, of six inches aperture and thirty inches focus; the figure of its metal was exquisitely perfect, whilst twelve years of constant use, had not occasioned the slightest tarnish of its almost colourless surface.

Accustomed as the first business of the night, to point a telescope to such of the principal planets as are above the horizon, on the 17th of March of the present year I had the satisfaction of seeing in the field of the 5-feet Equatorial, with the planet Mars, several stars, some of them minute, but one of the 5th and another of the 6th magnitude. Convinced that the planet would pass close by, or perhaps occult the larger, I took its place, and found it to be 37 Tauri. The covering under which the dome for my large equatorial was being built, unfortunately rendered the 5-feet equatorial useless, when the planet had approached within forty seconds of the star. The observations therefore were continued with the 12-feet Achromatic of $7\frac{3}{4}$ inches aperture, and also with the 42-inch of $2\frac{3}{4}$ aperture, till the star was one diameter and a half of the planet from his nearest limb; when, fearing lest the trees to the north-west of my grounds, might intercept the planet from my view, at the instant of nearest appulse or occultation, the 8-feet Achromatic of six inches aperture previously placed on the top of the house, was recurred to. The star, from being a full diameter distant from the planet when first observed with this telescope, was watched most unremittingly till the planet, having been in contact with it, had receded from it a quantity equal to its own semi-diameter. The star suffered not the least change of colour, nor the least diminution of its lustre, except what of the latter might fairly be attributed to the splendour of the planet; its rays were certainly in contact with the planet's limb, but only at their circumference; at times the planet and star were very steady, at other times far otherwise; but at no period was there such contrast between the steadiness of the star and the unsteadiness of the planet, as occurred at the occultation of 42 Leonis. As the star's distance from the planet diminished, the former seemed to undergo not the slightest alteration; and when in actual contact, both the star and the planet were red, but the planet had the deeper tint. The night was remark-

ably fine, and although Mars had not more than seven or eight degrees of altitude, a power of 320 was used with advantage.

The diameter of Mars, as taken with the 5-feet Equatorial, was about ten seconds. The observations were commenced at about seven hours sidereal time, whilst the nearest appulse was perhaps at about eleven hours ; they were not made for determining the place of Mars, but for noticing any phenomena which the star might exhibit.

The facts being now before us, the inferences may be comprised in a few lines.

Sir W. HERSCHEL's observation of the 27th of October 1783, and mine of the small star on the 19th of February 1822, are at variance with CASSINI's observation, but impugn not the accuracy of RÖEMER's ; whilst my observations of 42 Leonis and of 37 Tauri, being apparently subversive of the observations both of CASSINI and of RÖEMER, point out the "*extensive* atmosphere of Mars" as a subject meriting further investigation.

Such are all the observations relative to the *extensive* atmosphere of Mars which my observatory can furnish. One of these, viz. that of the 17th of last March, demands further consideration, lest, having served to invalidate one hypothesis, it might be brought forward to support another ; namely, that "the red colour of the planet Mars is dependent upon the physical properties of his atmosphere."* Moreover, it seems inconsistent with a previous observation.

The star 37 Tauri had "nearly the colour of Mars" whilst in contact with the planet ; whereas, the star 42 Leonis was "beautifully blue" previously and subsequently to occultation by the planet. The facts are different ;—are they reconcilable ? The following then are extracts from the Observatory Journal. On the night following the observation of 37 Tauri, namely, the 18th of March, "the five-feet Equatorial was placed upon Mars, in order to compare its colour with that of 37 Tauri ; the star and planet were still in the field together, though nearly at opposite points of its circumference. "I can have no hesitation in saying, that the star is red, but not of so deep a tint as the planet."

"Mars being placed out of the field, I requested an attendant (accustomed to use a telescope) to look at the star and to tell me its colour ; entirely un-

* Vide BREWSTER's Encyclopædia, vol. ii. pages 636 & 637 (article Mars).

acquainted with the bearing of the question, and ignorant of the colour assigned to it by me, he replied, ‘Certainly a light red.’ Mars was now brought into the field with the star, and being asked what colour he now considered the star to have, he answered, ‘Certainly red, but not so deep a red as Mars.’ Looking at it again, he said, ‘Mars is the darker, but there is not a great deal of difference.’”

“I now applied several other eye-pieces, magnifying from 70 to 548 times, and with all of them I felt convinced that the star was red, but not so deep a red as Mars.”

“Whilst the colour of 37 Tauri was fresh in my recollection,” I placed the Equatorial upon 42 Leonis, when it had nearly the same altitude as that star; I instantly pronounced the star 42 Leonis to be blue—light blue. The attendant was now requested to look again at 37 Tauri, and to retain its colour in his mind as much as possible: 42 Leonis was next brought into the field; he said, “This star is certainly not red at all; I do not know what colour it is, unless a light blue.” Alternating the examination of the one star with that of the other several times, and with various powers, he at last said, “It is certainly blue, and the first is certainly red.”

The comparisons were repeated with the 12-feet Achromatic of $7\frac{3}{4}$ inches aperture, and the inferences drawn from them were the same; and, if just, the observations of 37 Tauri and 42 Leonis are perfectly reconcileable. Hypothesis, therefore, is not needed, to explain under similar circumstances with regard to Mars, the “red” colour of the one star, or the “blue” colour of the other.